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WASTE WATER FILTRATION ENHANCEMENT

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Abstract

Removal of submicron particles from process solutions an
water is now economically achievable using a new Tyvek®
conventional filtration equipment. This new product
enhances filtration and allows use of the much improved fil
and polymers which were recently developed. It has
operating costs and ensures a clean effluent discharge
environment. This significant technical development is
important to those who discharge to a small stream with lo
flow and must soon routinely pass the Toxicity tests that a
required by many States for NPDES permit renewal.

The Savannah River Plant produces special nuclear materials
U. S. Government. Aluminum forming and metal finishing o
in M-Area, that manufacture fuel and target assemblies
nuclear reactors, discharge to a waste water treatment facili
BAT hydroxide precipitation and filtration. The new Tyvek
and filter aids have achieved 55% less solids in the
discharged to Tims Branch Creek, 15% less hazardous wa
filter cake), 150%-370% more filtration capacity, 74% lower
purchase cost, 10% lower total M-Area manfacturing cost, a
improved safety. Performance with the improved polymers
being evaluated.

Area Waste Water Treatment

el and target assemblies for the nuclear reactors of the Savannah
er Plant are fabricated in 300-M Area which has three production
ldings and two support laboratories. In two of the buildings,
nium and lithium alloys of aluminum are cast, extruded and
wn into long tubes with aluminum cladding. In the other
lding, short tubular shaped uranium cores ~~and~~ are nickel plated and
d in aluminum cans by hot die size bonding.

lute effluents from these metal finishing and aluminum forming
erations flow to an end-of-pipe industrial waste water treatment
cility. Metal hydroxides and phosphates are removed by the EPA
proved best available technology (BAT) economically achievable.
eatment consists of waste water equalization, physical/chemical
ecipitation, flocculation and pressure filtration. Insoluble metal
ides from autoclave test effluent are removed by a separate waste
ater equalization and pressure filtration system. The combined
trates are analyzed and discharged to Tims Branch Creek. Waste
ater treatment facility flow sheets are shown in Figures 1 and 2.

Figure 1. DILUTE EFFLUENT TREATMENT FACILITY

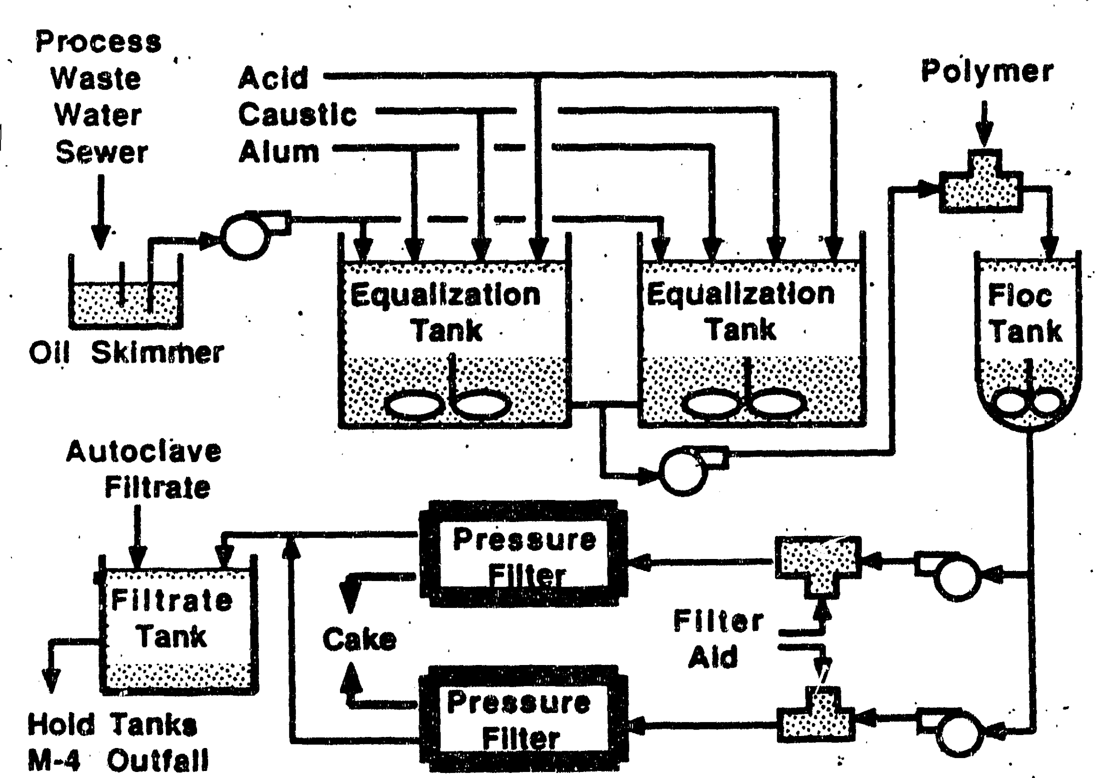
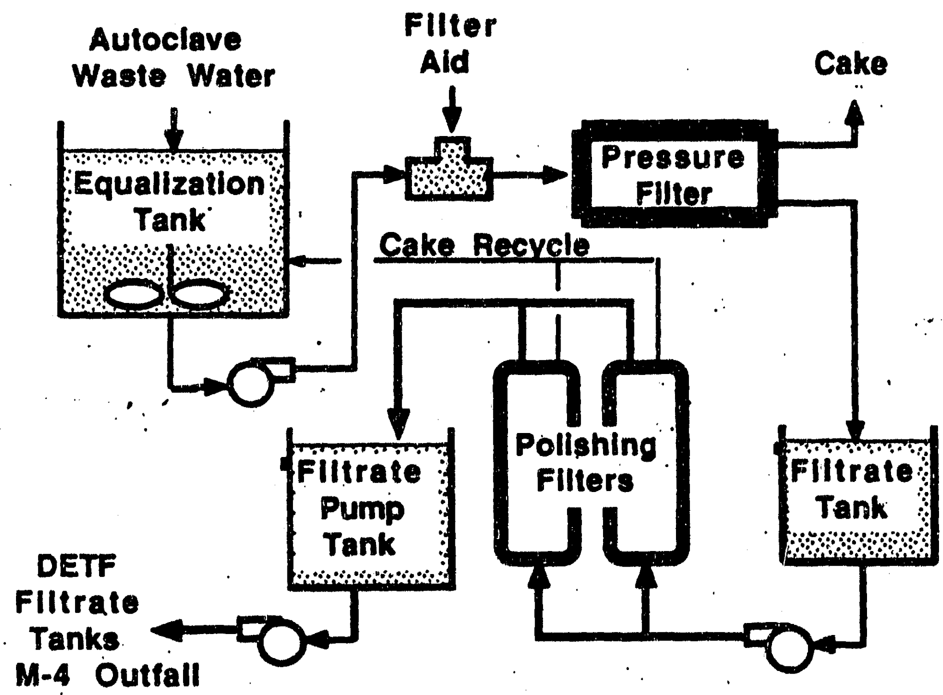


Figure 2. AUTOCLAVE WASTE WATER FILTRATION



Waste Water Sources

Production lines and equipment that are major sources of waste water are shown in Table 1.

Table 1. 300-M AREA WASTE WATER SOURCES

THREE PRODUCTION BUILDINGS & TWO LABORATORIES

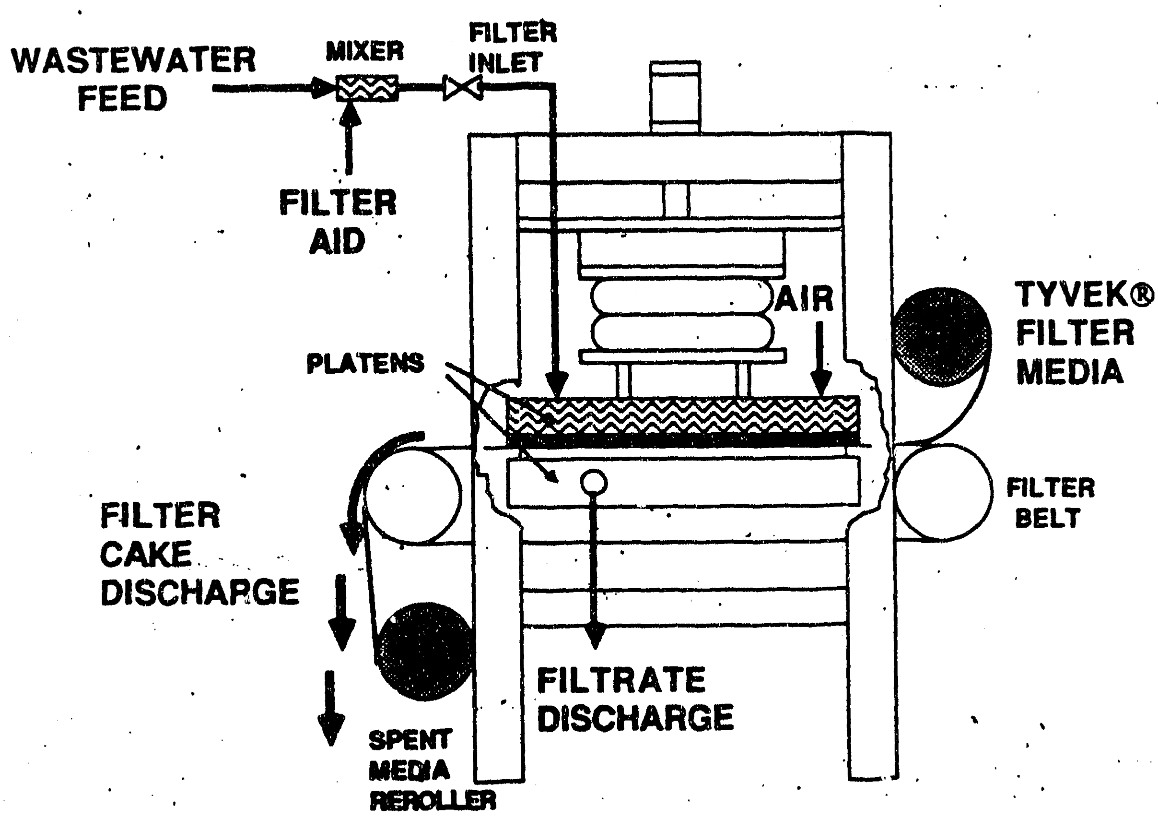
ONE	NICKEL PLATING LINE
FIVE	ALUMINUM CLEANING LINES
ONE	SLUG QUENCH OPERATION
ONE	URANIUM SLUG AUTOCLAVE TEST FACILITY
ONE	ALUMINUM/NICKEL STRIPPING LINE
TWO	STACK ACID SCRUBBERS
ONE	TOOL CLEANING LINE

Uranium cores, that have been pre-etched in nitric, phosphoric and hydrochloric acids, are nickel plated in a Watts bath. Aluminum tubes, caps and cans are cleaned by degreasing in 1,1,2-trichlorotrifluoroethane, etching in caustic, desmuting in nitric acid and surface treating in phosphoric acid. After aluminum forming operations, quench water cools product. Finished product is tested in steam autoclaves, and waste water from failures contains uranium, nickel and aluminum oxide particles. Some uranium cores are recovered from rejected product by stripping of aluminum and nickel cladding in caustic and nitric acid etch tanks. Air exhaust from hot nitric acid tanks is scrubbed in two stage dimesters. Aluminum forming tools are degreased and etched in caustic.

Filter Operation

The pressure filter is the primary unit operation in M-Area waste water treatment. Waste water containing the metal hydroxide and/or phosphate or metal oxide particles is mixed with filter aid at the inlet to the Oberlin® pressure filters, as shown in Figure 3. This mixture is distributed over a thin 24 square foot sheet of filter media. As filter cake accumulates, pressure in the upper platen increases. At 30 psig the waste water inlet vale closes completing the feed cycle, and the index cycle begins. Air discharges residual waste water from the upper platen and drys the cake. The filter then opens, and the media support belt advances discharging the cake. New media is drawn from a supply roll into the filter, as spent media is collected on a re-roller. The filter closes and the next feed cycle begins.

Figure 3. PRESSURE FILTER



Filter Media Selection

A proper selection of media is the most important factor in filter performance. Selection criteria are:

- How much waste water can flow through it (permeability).
- How small a particle can it retain (filtration efficiency).
- How long can it last (filtration capacity or life).
- How much does it cost (filtration cost).

Metal hydroxides and phosphates in M-Area waste water are flaky 1-5 micron particles, and the metal oxides are 0.5-2 micron cinders. The extremely high standard of separation needed to reliably achieve NPDES permit limits, hence, requires use of microporous filtration media.

Microporous Filtration Media

The major *microporous membranes* are manufactured by a *wet-cast* process or *biaxial stretching* which are relatively slow, inefficient and generally expensive ($7-40/yd^2). A new technology utilizing ultra-violet light for crosslinking of monomer and oligmers at a high operating speed has recently lowered the media cost. Even so, they must be protected against rough handling and are not very practical or economical for industrial waste water treatment.

Nonwoven media are an alternative lower cost choice. The are three basic manufacturing technologies: *melt spinning, melt blowing and flash spinning.*

Melt spinning involves extruding filaments through spinneret orifices followed by quenching the filaments with cross-flow air and drawing through an aspirator jet by concurrent air streams. The descending filaments are electrically charged to separate them and laid down in a completely random configuration onto a moving belt, under which is a suction box. The fibers are relatively coarse because fineness is limited by the capillary size in the spinneret.

Melt blowing produces a finer diameter fiber with better uniformity at lower basis weight. Molten polymer is extruded through spinneret orifices and the extrudate fibrillated by high temperature and high velocity air streams. Fine diameter, discontinuous fibers are laid down on a moving belt equipped with a suction box. The melt blown fibers have less strength than melt spun fiber and are often used in combination with other stronger fiber webs.

The melt blown fiber diameter is small, but *flash spinning* produces thirty times more surface area per unit weight. Internal voids in the fibrils are created by rupturing solvent vapor globules within the polymer solution during the flash spinning. The process involves decompression of a partially separated two-phase system of pure solvent droplets and highly saturated polymer/solvent mixture through a spin orifice which induces flash evaporation of the solvent and fibril formation. The fibrils become highly oriented which accounts for their high strength. The fibrils formed are micro-denier and are interconnected in a continuous network described as a form of plexifilamentary fiber structure. The fibril webs are collected on a moving belt are converted to a finished form using heat and pressure to promote self-bonding. This fine plexifilamentary fibril morphology has high filtration efficiency and good sheet tensile and tear strength.

Tyvek® Filter Media

Tyvek® spunbonded olefin is *flash spun* from high-density polyethylene. Because of its superior qualities, Tyvek® filter media was selected for use in M-Area waste water treatment facilities. It has performed very well and has maintained a very clean effluent since startup in July, 1985.

Recently a new Tyvek® product has been developed by multistage *stretch bonding* technology specifically for filtration applications. This process increased permeability by creating more submicron pores with a smaller average pore size. An asymmetric structure has been achieved which also increased the dirt holding capacity and filter life. The performances of the new Tyvek® T980 media and the original Tyvek® 1042B, while filtering the same waste water batch, are compared in Table 2. Average waste water flow through the filter increased about 10% with a cleaner filtrate, and media life (waste water volume per filter cycle) increased 25%.

The performance of media from the major manufactures during challenge tests for removal of metal hydroxide solids from metal

Table 2. TYVEK® MEDIA PERFORMANCE

M-AREA DILUTE WASTE WATER

MEDIA	FEED CYCLE min	AVG RATE gpm	INCREASE gpm	FILTRATE TURBIDITY NTU
TYVEK® 1042B	12.9	14.2*	----	0.12
TYVEK® T980	14.8	15.8*	11	0.11

* Total flow through both filters.

AUTOCLAVE WASTE WATER

MEDIA	FEED CYCLE min	AVG RATE gpm	INCREASE gpm	FILTRATE TURBIDITY NTU
TYVEK® 1042B	60	21.8	----	2.1
TYVEK® T980	57	23.8	9	1.3

finishing and aluminum forming waste water (600 mg/l TSS) in an Oberlin® pressure filter are shown in Table 3. *Tyvek® T980 produced a cleaner filtrate with the best cake release from media, less residual solids in the spent media, and more solids in the filter cake (less hazardous waste disposal).*

Table 3. MEDIA CHALLENGE TESTS IN OBERLIN® PRESSURE FILTER*

MEDIA Type	Nom. Rating** (μ)	ΔWt. Gain (mg)	Cake Release	Cake % Solids	Filtrate Turbidity (NTU)	Avg. Rate (gpm/sq ft)	Final Cake Air-Blow Pressure*** (psig)
Wet-Cast Microporous Membrane	0.45	50	Good	30	0.46	0.73	30
Flash Spun Tyvek® T980	1	10	Excellent	34	0.41	0.60	27
Biaxial Stretch PTFE Membrane Laminate	0.8	60	Fair	28	0.51	0.78	26
Melt-Blown PP	1.0	560	Fair	32	0.49	0.72	25
Melt-Blown PP	~5	445	Good	29	5.0	0.80	26

* Three-to-one weight ratio of diatomaceous earth filter aid (Celite® 577) to suspended solids was used, the optimum for these metal hydroxide particles.

** ΔWt. Gain is media weight gain after cake removed, and Cake Release judged visually after bending media to simulate discharge around roll.

***A measure of air flow through media and cake.

Media properties measured by standard test methods are also compared in Table 4. Note that *Tyvek® T980 matches the permeability of competing media*, especially water permeability which is the most important.

Table 4. FILTER MEDIA PROPERTIES MEASURED BY STANDARD TEST METHODS

Media	Nom. Rating (μ)	Frazier Air Flow (cfm/sq ft)	Bubble Point in Water (psi)	Water Permeability (gpm/sq ft @ 1 psi)	OSU ACFTD Micron Removal @ Stated ß (% Efficiency) 10 (90%)	100 (99%)	1000 (99.9%)	∞ (100%)
Wet-Cast Microporous Membrane	0.45	0.25	23	0.8	~0.45	---	---	---
Flash Spun Tyvek® T980	1	1.0	4	1.0	1.4	2.1	11	14
Biaxial Stretch PTFE Membrane Laminate	0.8	1.0	5	1.5	0.8	1.3	8.3	26
Melt-Blown PP	1	5	0.7	14	---	---	---	---
Melt-Blown PP	~5	18	0.4	30	9.7	13.5	15.9	17.2
Millipore HA	0.45	---	33	1.0	~0.45	---	---	---

This OSU ACFTD (AC Fine Test Dust) procedure, originally developed for multipass oil filtration, is the nornally accepted challenge test used by filter suppliers. Most end-users are interested in dirt capacity (or life), so this too was evaluated by the ACFTD challenge to 30 psi differential pressure tests at 60 and 600 mg/l levels. These tests were conducted on both the Pall® 47 mm Disc Filtedability Kit and the full scale Oberlin® pressure filter. As shown in Table 5, the *Tyvek® T980 filtration capacity (life) is less than the other media; but it costs much less.*

Actual media costs per gallon of waste water filtered are compared in Table 6, and *Tyvek® T980 is clearly the most economical.*

M-Area costs are now even less than shown in Table 6, because Tyvek® T980 has allowed use of an improved filter aid that was recently developed. This lower cost filter aid has increased media filtration capacity (life) and total permeability (average waste water flow).

Table 5. MEDIA FILTRATION CAPACITY (LIFE) BASED ON ACFTD CHALLENGES*

Media	Nom. Rating (μ).	60 mg/l Time to 30 psi (min) Pall®	Oberlin®	Avg. Factor	60 mg/l Time to 30 psi (min) Pall®	Oberlin®	Avg. Factor
Wet-Cast Microporous Membrane	0.45	92	67	1.0	12.0	17.5	1.0
Flash Spun Tyvek® T980	1	23	15.5	0.24	---	6.5	0.37
Biaxial Stretch PTFE Membrane Laminate	0.8	72	52.3	0.78	10.0	12.0	0.69
Melt-Blown PP	1	88	---	0.95	13.5	20.0	1.14
Melt-Blown PP	~5	140	---	1.50	14.5	21.3	1.22

Table 6. MEDIA COSTS PER GALLON WASTE WATER FILTERED

Media	Nom. Rating (μ).	General Filtrate Quality	Actual Costs per Gallon Filtrate (cents/gallon)
Wet-Cast Microporous Membrane	0.45	Excellent	69
Flash Spun Tyvek® T980	1	Very Good	0.7
Biaxial Stretch PTFE Membrane Laminate	0.8	Very Good	63
Melt-Blown PP	1	Good	6.5
Melt-Blown PP	~5	Poor	4.0

Filter Aid Selection

Economical removal of submicron metal solids from waste water also requires a well matched filter aid. If filter aid particles are too large, fine solids in waste water will pass through and quickly blind pores of the media. If the filter aid itself contains too many fine particles, it will blind the media. Fine grades of diatomaceous earth have demonstrated excellent filter aid performance in the metal finishing industry. However, national reserves are diminishing and prices are rapidly increasing. These fine grades should be reserved for those applications for which there is no economic substitute.

Fine grades of diatomaceous earth were initially used as filter aids in M-Area waste water treatment with the Tyvek® 1042B media. When waste water contained greater than 3 micron particles, Standard Super-Cel® was used; and when a significant concentration of 1 to 3 micron particles (nickel and iron) were present, Celite® 577 was used. Both performed well, but experienced technical surveillance was required to maintain proper match of filter aid to the frequent changes of particle size distribution in the waste water.

Recently PerFLO® 30 filter aid was produced by an inventive expanded Perlite manufacturing method. This high grade filter aid is less expensive, and has an excellent segregated particle size with few fines. The performances of PerFLO® 30 filter aid with the new Tyvek® T980 media and Celite® 577 with Tyvek® 1042B, while filtering the same dilute waste water batch, are compared in Table 7.

Table 7. FILTER AID PERFORMANCE

M-AREA DILUTE WASTE WATER

MEDIA	FILTER AID	FEED CYCLE min	AVG RATE gpm	INCREASE gpm	FILTRATE TURBIDITY NTU
TYVEK® 1042B	Celite® 577	5.0	14.2*	----	0.20
TYVEK® T980	PerFLO® 30†	9.8	35.2*	150	0.11

* Total flow through both filters.
† 20% wt. less filter aid.

AUTOCLAVE WASTE WATER

MEDIA	FILTER AID	FEED CYCLE min	AVG RATE gpm	INCREASE gpm	FILTRATE TURBIDITY NTU
TYVEK® 1042B	St. Sup. Cel®	---	7.4	----	2.6
TYVEK® T980	PerFLO® 30†	---	24.0	220	8.9
TYVEK® T980	Celite® 577	---	35.0	370	0.8

† 20% wt. less filter aid.

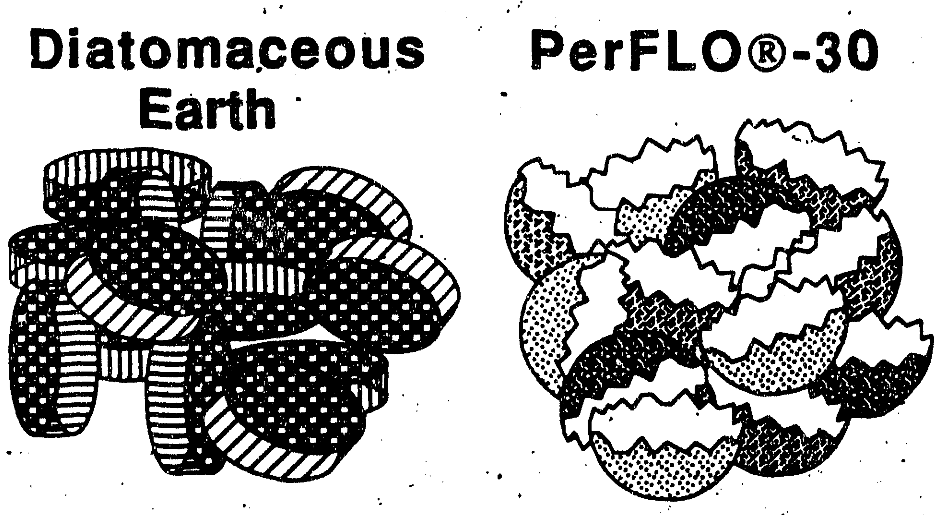
Filtrate contained 45% less suspended solids. Average flow through the filters doubled with five time as much waste water per filter cycle (80% less media used). 20% less filter aid was needed (2.4-to-1 weight ratio PerFLO® 30 to total suspended solids in waste water).

This usage was verified by monitoring consumption for three month before and after transition to the new materials. Only when treated waste water contained less than 400 mg/l total suspended solids was it not practical to use less filter aid.

Although it greatly improved the dilute waste water filtration system of Figure 1, PerFLO® 30 could not be used in the autoclave waste water filtration system of Figure 2. That system has a 0.5 micron sintered metal polishing filter downstream of the pressure filter that recycles the very fine metal oxide particles. Diatomaceous earth is the siliceous remains of planktonic algae with many microscopic pores in which trap these fines and discharge them with the filter cake. PerFLO® 30 is solid particles of sodium potassium aluminum silicate that resemble microscopic broken egg shells, as illustrated in Figure 4. These solids do not scavenger the very fine particles. Recycled fines accumulated in the system increasing the filtrate turbidity from the pressure filter, as shown at the bottom of Table 7. The metal concentration in filtrate from the polishing filter then increased.

The importance of matching the filter aid and media to the particle size distribution in waste water is also shown in Table 7. By changing from Standard Super-Cel® and Tyvek® 1042B to the finer grade Celite® 577 and new Tyvek® T980, waste water flow increased 370% and total less suspended solids in the filtrate from the pressure filter decreased 70%. Filter cake is now recycled less frequently from the polishing filter.

Figure 4. FILTER AIDS



Metal Recovery

In addition to waste water treatment, Tyvek® T988 (thicker grade of the new media) is being used to remove submicron metal particles from the grinding and pollishing machine effluents of M-Area support laboratories. No filter aid is added to this 2.4 ft^2 Oberlin® pressure filter.

Cost Savings

Solids removal capacity of M-Area waste water treatment facilities has been greatly increased by the improved filter aid and media without the costly addition of another pressure filter. Filter cake to hazardous waste storage for future disposal decreased 15%. Price of PerFLO® 30 filter aid is half that of the fine grades of diatomaceous earth, and 20% less is needed. The new filter media also costs less to manufacture, and 80% less is now used. *Total purchase cost of filter aid and media decreased to less than 0.5¢ per gallon of waste water processed.* If Tyvek® T980 and PerFLO® 30 had been used when M-Area operated at normal production rates in 1986, the estimated annual savings are $350,000.

This new micro filtration media has also made a 75% volume reduction of the million gallons of stored hazardous waste technically feasible. Millions of dollars of future sludge treatment and disposal costs can now be saved.

Significant Advancement of Technology

This significant technical development has made removal of submicron particles from process solutions and waste water economically achievable using the new Tyvek® media in conventional filtration equipment. This technology is especially important to those who discharge to a small stream with low 7Q10 flow and must soon routinely pass the Chronic Toxicity tests that are being required by many states for NPDES permit renewal.

Microporous Tyvek® media provides a reliable high strength barier that ensures a clean effluent stream. Pressure filters also require less space than clarification equipment, and total construction and operating cost assessments now frequently reveal that filtration is the more economical solid-liquid separation technology.

After visiting M-Area waste water treatment facilities, EPA has chosen the Oberlin® pressure filter using the new Tyvek® media for Superfund Innovative Technology Evaluation (SITE).

Polymer Selection

Laboratory tests indicate that addition of recently developed polymers to the treated waste water will greatly enhance filtration. An anionic polymer was initially used, but the polymer activation tank was too large. After activation with water, the polymer aged and formed an unfilterable slime in waste water if not used within four to seven days.

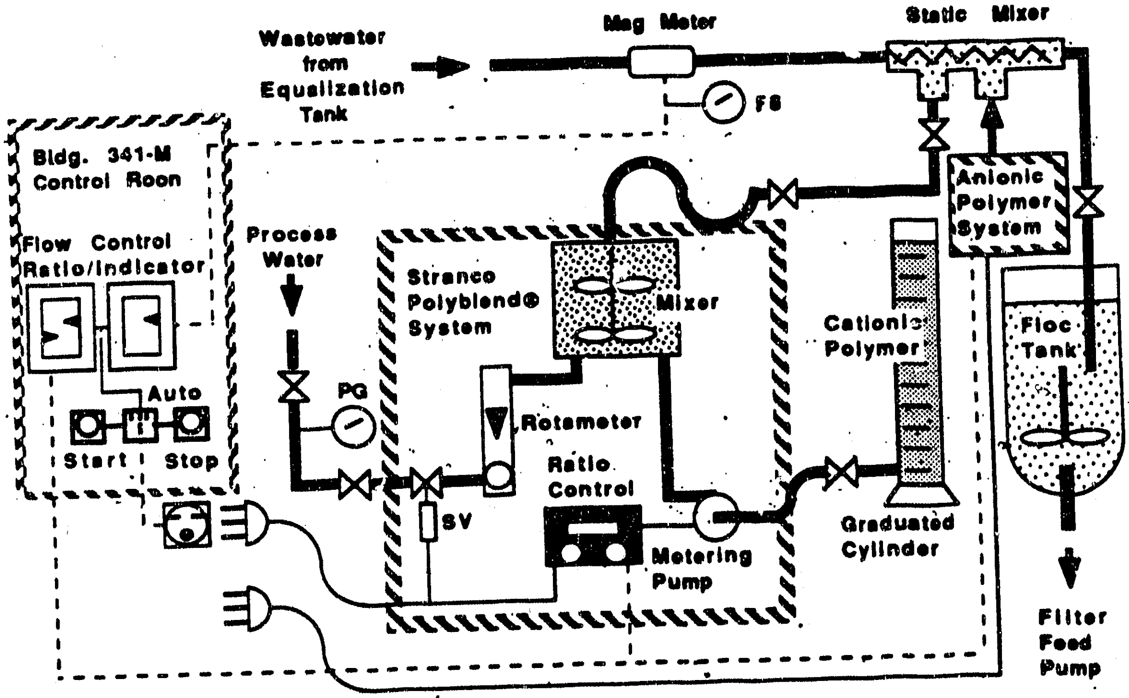
Significantly improved polymers and activation systems are now available. Laboratory tests indicate that 0.5 mg/l Praestol® A3040L anionic polymer will *triple the filtration rate* of metal hydroxide waste water at 500-600 mg/l TSS, and 8 mg/l Praestol® K144L cationic polymer will *double the filtration rate* of metal phosphate waste water at 800-1000 mg/l TSS when used with PerFLO® 30 filter aid and Tyvek® T980 media. Hence, additional reduction in filter aid and media usage are expected.

Separate anionic and cationic polymer addition systems are being installed for full scale evaluation. Uniquaely constructed PolyBlend® systems will activate the polymer and inject it into an inline static mixer upstream of the flocculation tank that feeds the pressure filters, as shown in Figure 5.

The polymer pump receives a signal proportional to the waste water flow and adjusts its metering stroke frequency and length to maintain the desired polymer concentration in waste water. When the pressure filter cycles to discharge cake, there is no waste water flow; so process water addition to the mixing chamber then also automatically stops. A reliables system is especially important for the anionic polymer, because greater than 2 mg/l in the waste water will blind the filter media rather than enhance filtration.

The combination of rapidly activating polymers and the specially designed mixing chamber, that stretches the polymer molecules to speed activation, has greatly reduced the cost of the addition systems. These systems have proven reliable and easy to operate in similar waste water treatment facilities. The improved polymers have now made the PolyBlend® systems usable in M-Area.

Figure 5. Polymer Addition System – Schematic Drawing



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